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COVID-19 Active Case Algorithm

General Background

Since March 30, 2020, the State of Vermont has required a 14-day self-quarantine for anyone traveling into the state in response to the COVID-19 pandemic. Effective June 8, 2020, the State of Vermont has lifted the 14-day quarantine for personal auto travel to and from counties in New England and New York which have fewer than 400 active COVID-19 cases per million. The Vermont Department of Health has determined there is a sufficiently low risk of transmission in those counties with fewer than 400 active COVID-19 cases per million to allow for safe cross state travel between these regions.[1]

About the Map

The dynamic case map displayed on the Vermont Department of Financial Regulation and the Vermont Agency of Commerce and Community Development websites allows anyone to determine the current travel status of any county in New England or New York under Governor Phil Scott's current self-quarantine regulations. The most recent infection data is pulled once a week from Johns Hopkins University's COVID-19 GitHub repository, then put through our viral load algorithm to determine the number of active cases per million. Travelers from counties colored green are exempt from the 14-day self-quarantine, while those from counties colored in yellow and red must continue to abide by the restrictions. Vermont is colored blue as the travel policy does not apply to Vermont counties. Reopening in Vermont is instead monitored by the following metrics: 1) syndromic surveillance, 2) case growth, 3) percentage of positive tests, and 4) hospital resource capacity.

About the Algorithm

The Department of Financial Regulation determines which counties are above or below the 400 active cases threshold by using daily confirmed case data at the county level from Johns Hopkins University and then applying an estimated viral load algorithm. Updates are released weekly, and travel guidance is considered current until the next update.

Current research has determined that individuals are most infectious around their symptom onset date, and that their infectiousness begins to decrease within a few days after onset. Since the main concern is preventing new infections in Vermont, recent cases must be weighted more heavily than older cases. Our algorithm thus calculates how infectious a confirmed case is over time based on the symptom onset date (this is often referred to as "shedding" the virus). As such, a county with an outbreak yesterday would be deemed a

[1] Other regions have adopted similar thresholds for safe travel—--Germany has recently begun to allow travel from EU nations with fewer than 500 new confirmed cases per million within the last week.

greater risk to Vermonters than a county which has not had any new confirmed cases for over a week, even if they report the same number of total active infections.

Developing the Algorithm

In order to model how infectious someone is after a given time, the modeling team consulted a list of known transmissions between two individuals provided by the Vermont Department of Health. By looking at the time from the infector's initial symptoms to infectee's initial symptoms, it's possible to determine how long it took to pass on the virus. Consulting many ``infector-infectee pairs'' allows us to measure how likely the infection is to spread at any given point. (Note: this frequency distribution is commonly known as a serial-interval distribution and is useful for calculating the effective reproduction number, or R_t, of an epidemic.)

The distribution of infection times most closely fits a gamma distribution, a mathematical model in which patients first undergo a short period of high infectiousness followed by a longer period of much lower infectiousness. We run each case along this distribution to determine how infectious the patient is. A patient presenting with symptoms 14 days ago, for example, is less that one sixth as infectious as a patient who begins to experience symptoms today. While most active infection models would count these two cases as equal, ours can distinguish between patients that pose a significant threat to Vermonters and those that have already passed their most infectious period.

After weighing each case based on the date of symptom onset, our model adds them together. This number is combined with census data to determine ``weighted active cases per million.'' The model now has the correct distribution and relative values for county infection levels but needs to be normalized to bring total values into line with known metrics. To achieve this, the algorithm multiplies its outputs by a scale factor α that has been calculated based on Vermont's epidemiological data. This returns the final value of ``active cases per million'' in a county. It is this final number that is compared to the 400 cases per million threshold. The process is then repeated for all counties in New England and New York. The complete algorithm for active cases in a county is as follows:

$$\text{Active Cases } = \frac{\alpha * 10^6}{P} * \sum_{x=1}^{30} \left(\left(1 - \frac{1}{\Gamma(k)} * \gamma\left(k, \frac{x}{\theta}\right) \right) * I_x \right)$$

Where I_x represents new infections x days ago as measured by the Johns Hopkins epidemiology team, P is the population of the county, k and θ are the shape and scale parameters of the gamma distribution, and α is the scale factor. Variables are subject to change based on new data in order to ensure the most accurate possible estimation.

What this Map Isn't Intended to Do

As this algorithm and map are designed for the sole purpose of monitoring regional travel requirements, viewers should keep a few things in mind. The map does not provide live information—updates are released weekly. Since active case counts are adjusted for population, this map also does not provide the number of total or active cases in any county. The map may disagree with data put out by municipal governments due to varying definitions of "active case" or differences in reporting timeframes. Our data is drawn from Johns Hopkins University, an internationally trusted resource, to ensure that data for all counties is obtained from a single source at a single point in time.

Please direct all questions to dfr.pubinfo@vermont.gov